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The goal of the AASERT training is to combine work in oculomotor control and visual modeling. The research concentrates on the question of how saccades are able to be programmed accurately to target objects in natural scenes. There are two steps to this process, namely, selection of the goal object and spatial pooling of information in the selected object. the selection state is studied by means of "dual-task" experiments, using techniques developed in mathematical psychology to measure performance trade-offs of concurrent tasks. The pooling stage is being studied bymeans of experiments in which saccades are used to look at targets of varying size, contrast, and spatial frequency content. The goal is to discover the processing steps used by the visual system to compute a central landing position.

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October 6, 1994

Lt. Col. Dan Collins
AFOSR / NL
Bolling AFB, DC 20332

Re: Technical progress report for F 49620931 (AASERT)
"Interdisciplinary training in visual sciences"

Dear Dan:

The progress for the first year of F49620931 is as follows:

Students supported: 2 graduate research assistants (Dan Bahcall and James McGowan), and 2 undergraduate assistants (Eric Anderson and Chris Araujo).

Summary of project objectives: All projects relate to the problem of using eye movements to scan natural environments, the topic of the parent grant (PI: Kowler). We want to know how the saccadic system directs the eye to objects of interest in the visual field. Directing the eye accurately has two components. The first is a selection process that defines which of the many stimuli in the visual array constitutes the effective saccadic target. The second is a pooling process that combines information in the selected object to produce a single saccadic landing position. At the same time that work on the oculomotor projects is proceeding, the students are acquiring a firm background in mathematical approaches to visual problems by means of interactions with scientists (in and outside Rutgers) with expertise in mathematical psychology (B. Dosher, Irvine) and visual modeling (Chubb, Rutgers; Bergen and Lubin, Sarnoff Labs). The description of specific projects follows.

Selection: We have completed a paper (Kowler, Anderson, Dosher and Blaser, under review) describing a series of experiments showing that the effective target for saccades is determined by shifting perceptual attention to the chosen target object. This was shown by using novel methods (including the "Attentional Operating Characteristic") to demonstrate performance trade-offs when trying to make a saccade to one location while simultaneously trying to recognize a target in another. Surprisingly, the trade-offs, although real, are

modest, i.e., paying a small amount of attention to the saccadic goal is sufficient to produce an accurate saccade. This is a useful outcome, which ensures availability of attentional resources for perceptual processing across the visual field. The results may be explained by a model in which a saccade is triggered when attention moves to the appropriate location. This model requires separate hand-shaking systems for the control of "when" and "where" saccades occur. A portion of these experiments constituted Anders undergraduate honor's thesis.

Bahcall is continuing the investigations of selection by studying the perceptual analog to the saccadic experiments described above. Rather than have someone try to look somewhere and recognize a target elsewhere, Bahcall is having them try to recognize targets in two different spatial locations. The goal is to discover the size of the effective "attentional receptive field", i.e., the size of the region over which we are able to distribute attention at different retinal eccentricities. Field size is relevant to the targeting of saccades because in natural scenes, targets are objects of some spatial extent. If the target object is larger than the limits of the attentional field at a given eccentricity, then saccadic accuracy or precision should suffer. Bahcall discovered something surprising and remarkable. Namely, if two targets are near one another, identification is not facilitated (such as would be the case if the targets fell in the same attentional field) but instead is inhibited. Performance actually improves the farther the targets are from one another. This is as far as we know the first demonstration of local attentional inhibition and is a potentially important breakthrough for the understanding of how attention affects both perception and motor control.

McGowan is studying the spatial pooling process, i.e., the process that operates on the information in the attended stimulus to compute a single, precise saccadic landing position. One set of experiments is being done to determine the size of the effective pooling region. The task is simply to direct the eye to a various clusters of randomly-positioned dots. McGowan is looking for correlations between dot locations and saccadic landing positions in order to determine which locations contribute most to determining where the eye lands. Possibilities include a "center-surround" organzation, where dots from the center of the field are more important than dots from the surround. The alternative is a "contour-based" organzation, in which dots nearest the boundaries are most important. The outcome will be used to specify the processing steps used by the visuomotor system to compute the saccadic landing position. A second set of experiments is examining saccades to stimuli of different spatial frequency content and spatial contrast. Here the goal is to find out whether the pooling process occurs at a

relatively early stage of processing, where detectors are very sensitive to frequency and to contrast, or a later stage where frequency and contrast is known from experiments on perceptual localisation to be unimportant. Collaborators on this work include visual scientists with expertise in the study and modeling of low-level visual detection, namely, Dr. C. Chubb (Rutgers) and Drs. J. Bergen and J. Lubin of Sarnoff Laboratories in Princeton, NJ.

Araujo (Rutgers undergraduate), who has just joined the group, is now designing and setting up an experiment on visual search. He wants to find out whether oculomotor scan patterns are influenced by the probability of finding a target in different locations. While use of probabilistic information may seem sensible, it may well turn out that the saccadic system operates more efficiently by ignoring probabilities and instead using a well-learned stereotypical scanpath. The outcome of this study will tell us how sensitive saccades are to sensory variables (stimulus configuration) vs. cognitive variables (probabilities) and help specify precisely what defines the most effective search strategy.

Sincerely,

Eileen Kowler

Eileen Kowler, Ph.D.
Professor and
Principal Investigator

(Abstract on following page)

Progress report for F49620-931-0408, E. Kowler

Technical progress report for F 49620931 (AASERT)
"Interdisciplinary training in visual sciences"
PI: E. Kowler, Department of Psychology, Rutgers University, New Brunswick, NJ 08903

ABSTRACT

The goal of the AASERT training is to combine work in oculomotor control and visual modeling. The research concentrates on the question of how saccades are able to be programmed accurately to target objects in natural scenes. There are two steps to this process, namely, selection of the goal object and spatial pooling of information in the selected object. The selection stage is studied by means of "dual-task" experiments, using techniques developed in mathematical psychology to measure performance trade-offs of concurrent tasks. The pooling stage is being studied by means of experiments in which saccades are used to look at targets of varying size, contrast, and spatial frequency content. The goal is to discover the processing steps used by the visual system to compute a central landing position.